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# **Reducing SCADA System Nuisance Alarms in the Water Industry in Northern Ireland**

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**ABSTRACT:** The advancement of telemetry control for the water industry has increased the difficulty of managing large volumes of nuisance alarms (i.e., alarms that do not require a response). The aim of this study was to identify and reduce the number of nuisance alarms that occur for Northern Ireland (NI) Water by carrying out alarm duration analysis to determine the appropriate length of persistence (an advanced alarm management tool) that could be applied. All data were extracted from TelemWeb (NI Water's telemetry monitoring system) and analyzed in Excel. Over a 6-week period, an average of 40 000 alarms occurred per week. The alarm duration analysis, which has never been implemented before by NI Water, found that an average of 57% of NI Water alarms had a duration of <5 minutes. Applying 5-minute persistence; therefore, could prevent an average 26 816 nuisance alarms per week. Most of these alarms were from wastewater assets.

**KEYWORDS:** telemetry control, nuisance alarms, persistence, NI water, SCADA.

## 1   **Introduction**

2           The processes involved in water supply and wastewater treatment are now largely  
3   automated and demand very high quality control. These processes are also subject to  
4   environmental and productivity constraints. All stages must be regulated and monitored creating  
5   an immensely large volume of information that must be processed. Failing to process this  
6   information, such as missing alarms arising from operation abnormalities, can result in  
7   inadequate treatment of potable water which threatens public health, and wastewater overflows  
8   from wastewater pumping stations (WWPS) which pollute the environment. Northern Ireland  
9   (NI) Water has the responsibility to meet the water requirements for NI without detrimentally  
10   affecting the environment. Therefore, telemetry, the capacity of capturing, processing and  
11   sending system data via radio signal or telephone line, is becoming increasingly important as  
12   populations and water stations expand (Avlonitis et al., 2007; Boquete et al., 2003; Gray, 2005;  
13   Glasgow et al., 2004; Schneider Electric UK, 2013). Telemetric supervisory control and data  
14   acquisition (SCADA) systems are used by industries to collect and process data from their assets  
15   to ensure optimum process efficiency. The most critical function of any SCADA system is to be  
16   capable of producing alarms that serve to notify telemetry control operators (TCO) of abnormal  
17   process conditions or equipment malfunctions.

18           Nuisance alarms are alarms that do not require a response from the operator. They  
19   annunciate excessively and unnecessarily, and do not return to normal after the correct response  
20   is taken (EEMUA, 2013). Sources of nuisance alarms include instrument problems (faulty  
21   sensors, etc.), poor control, or poor tuning of alarm settings. The magnitude of these problems  
22   may vary depending on what alarm philosophy is used at the onset of the SCADA system  
23   development; however, typically for industries that require telemetry control systems, such as

power plants, they can account for 50% of alarm annunciations (Patel, 2011).

Persistence or ON-delay is the amount of time a signal is allowed to exceed an alarm trip point before an alarm is generated (Hollifield and Habibi, 2011; Northumbrian Water, 2009). For example, a persistence of 1 minute would mean an alarm signal would have to be in alarm or above the alarm threshold for 1 minute for the alarm to appear or annunciate on TCO screens (Figure 1). Persistence can be useful for preventing recurring nuisance alarms from annunciating (appearing on TCO screens) that otherwise could require increased logic or site visits and maintenance to mitigate. Therefore, most sensors available to water authorities already have built-in persistence (Schneider Electric, 2013). However, the length of persistence used also adds to the response time for genuine alarms, decreasing response efficiency and increasing risk. The factors that determine this risk are the length of persistence and the sensitivity of the point at which persistence is applied. Therefore, persistence is a double-edged sword; it will reduce alarms, but if used inappropriately, it will increase risk. The ON-delay was the alarm management tool selected for this project. The aim of this study was to carry out alarm duration analysis to determine the appropriate length of persistence that could be applied.

## **Materials and Methods**

The NI Water telemetry control system is configured to remotely monitor approximately 60 000 operational assets or points across NI (Figure 2). Many of these points have a single or a multiple alarm setting configuration. When the alarm thresholds are breached, an alarm is received in the telemetry control center (TCC). During this study, an average of 40 000 alarms were received in NI Water's two TCCs per week. This represents a risk to NI Water and is not compatible with the principles of alarm management as described by the International Society of

Automation (ISA) and the Engineering Equipment and Materials Users Association (EEMUA) (ANSI/ISA, 2009; EEMUA, 2013).

**Persistence.** At the start of this project, persistence was already in use on some NI Water points. Notably, a 30-minute persistence was placed on WWPSs because they were responsible for a high volume of alarms produced in the water stations. However, before this project, determining the all-important length of persistence to be used for NI Water applications has generally been trial and error, based on the experience of the operators involved, and with no detailed analysis carried out to support the length of persistence chosen. To determine which persistence would be most appropriate, analysis was carried out on alarms that occurred from the weeks starting on November 18 and 25 during 2012 and May 12, May 19, June 2, and June 16 during 2013 to attain results that better represented yearly (seasonal) change of alarm patterns.

**Alarm Analysis Procedure.** Alarm data were downloaded from TelemWeb (NI Water's telemetry monitoring system) with the use of system-based filters so only appropriate data were collected. This was then clipboarded and pasted into Excel 2010 (Figure 3). The duration of alarms was calculated by subtracting the time of the first "Raised" state (when alarm first annunciates; i.e., appears on TCO screens) from the subsequent "Cleared" (alarm returns to normal) state for any alarm occurrence. The results were then sorted into time based groups (<5 minutes, 5 to 10 minutes, 10 to 20 minutes, 20 to 30 minutes, and >30 minutes) counting each calculation based on its time group.

However, because one point can have several alarm thresholds configured (i.e., different alarms for different levels of a tank), it is possible that one point can produce several "Raised" alarm states before it "Clears". In other words, a single point may produce several alarms before returning to normal and clearing. Regardless of how many "Raised" states, there will only be one

1 “Cleared” alarm state when any point goes into alarm. This greatly complicated the logic  
2 required to determine the duration that a point was in alarm, because the number of “Raised”  
3 states for each alarm occurrence was random; therefore, advanced Excel techniques were  
4 required (Figure 3). The Excel logical functions used in this study included

- 6 • IF—Returns one value if a condition you specify evaluates to TRUE and another value if  
7 it evaluates to FALSE,
- 8 • ROW—Returns the number of rows in a reference,
- 9 • LEN—Returns the number of characters in a text string,
- 10 • TRIM—Removes spaces from text, and
- 11 • INDEX—Returns a value or the reference to a value from within a table or range.

## 13 **Results and Discussion**

14 **Seasonal Patterns of Alarms.** Once the duration of alarms was calculated, they were  
15 grouped into time ranges from <5 minutes, 5 to 10 minutes, 10 to 20 minutes, 20 to 30 minutes,  
16 and >30 minutes. Seasonal effects on the alarms were examined (Figure 4). The number of  
17 alarms occurring during autumn (November) of 2012 were notably higher than the number of  
18 alarms measured in the spring (May) and summer (July) 2013. This is the result of higher  
19 precipitation that occurred during November 2012, compared to May and June 2013, which  
20 increases the number of alarms from WWPSs. Analysis carried out from January to March at the  
21 onset of the project, previous to the sampling period for the alarm duration analysis, indicated  
22 that WWPSs were the second highest producers of alarms with water resource recovery facilities  
23 (WRRFs) as the highest offender. Water resource recovery facilities worldwide are notorious for

1 poor data quality and sensor malfunctions resulting from the harsh conditions associated with  
2 wastewater (Yoo et al., 2008). Because overflows at WWPSs are more damaging to the  
3 environment than overflows at WRRFs, WWPSs are fitted with various sensors with more alarm  
4 states such as high, very high, and overflowing (DPIWE, 1999). The vast majority of alarms  
5 generated from the wastewater assets are during wet weather because wet-well levels fluctuate  
6 greatly with each downpour (Dieu, 2001). The alarm settings on these points do not take into  
7 account the fluctuating nature of these assets producing numerous fleeting or short-lasting  
8 alarms. This is why the greatest portion of alarms in November were <5 minutes, with 57 and  
9 77% of total alarms occurring in the weeks of November 18 and 25, respectively. The number of  
10 <5-minute alarms were also highest (44 to 53%) for the weeks measured in May and June 2013,  
11 compared to longer durations. The alarms that occur under the other time ranges (i.e., 5 to 10  
12 minutes, 10 to 20 minutes, 20 to 30 minutes, and >30 minutes) were random, with no specific  
13 type of alarm associated with a specific time range. The >30-minute alarms were the next highest  
14 group ranging from 12 to 31%. Seasonally, there was very little difference within the 5 to 10-  
15 minute and 10 to 20-minute alarms and between those ranges. These alarms ranged from 5 to  
16 11% for 5 to 10 minutes and 3 to 10% for 10 to 20 minutes. The lowest number of alarms  
17 occurred for 20 to 30 minutes, with little variation between the weeks measured.

18 **Nuisance Alarms.** During this study, an average of 50 000 alarms were being generated  
19 by the telemetry systems each week, while an average of 40 000 of these alarms would be  
20 received in NI Water's two TCCs. These alarms would have to be dealt with by TCOs. Overall,  
21 the average percentage of alarms that were <5 minutes was 57%, representing an average of 26  
22 816 alarms measured in November 2012, and May and June 2013 (Figure 5). Although  
23 redundant and inhabitant alarms are often the major source of nuisance alarms (Johnson and



Hendrix, 2006), alarms that occur for 0 to 5 minutes can be considered nuisance alarms because it is highly unlikely a TCO could have fully responded. Apart from retrofitting pumping stations to handle wastewater flow more efficiently (Mayers et al., 2011) to decrease alarms, applying persistence may be more feasible and cost-saving. Therefore, an average of 26 816 nuisance alarms could be prevented from annunciating on TCO screens every week. This would result in TCO operator control screens being far less cluttered by nuisance alarms. Thus, although persistence is usually associated with increasing response time, by drastically reducing the number of nuisance alarms (which currently distract TCOs from genuine alarms), a 5-minute persistence could actually improve response time.

However, a concern expressed during the development of the persistence proposal was the loss of information from points as a result of persistence. This is because persistence is applied at outstations (i.e., service reservoirs), as opposed to the TCC where information from points is passed onto TCO screens and stored for record-keeping purposes and alarm analysis. Any alarm with a duration less than the length of persistence will be prevented at the outstation as described before. Not only is the alarm stopped from annunciating on TCO screens, but no record of the prevented alarm occurring is sent to the TCC. For instance, if the 5-minute persistence was implemented, there would be no indication of points going into alarm for only 4 minutes and the record of these suppressed alarms would be lost. This information is important for organizing maintenance schedules, because logical points that are producing abnormally high alarms are probably the result of faulty sensors et cetera, ; therefore, they should be given priority to be corrected as soon as possible (Hollifield and Habibi, 2011; Stauffer, 2012).

**Redirection: A Version of Persistence.** To counter this limitation, redirection, another advanced alarm management tool available to NI Water, was considered (Figure 6). As described

by Schneider Electric UK (2013), normally alarms are passed on from the outstation to the master station located within the TCC to TCO monitoring screens, which are also located within the TCC. However, redirection is applied at the master station, also located within the TCC, and can be used to redirect alarms from the master station to TCO computer screens. In this case, when an alarm reaches the master station, the SCADA system can wait for any time delay to expire before redirecting the alarm to TCO screens. If this time delay was 5 minutes, this form of redirection would have the same effect of 5-minute persistence (preventing 5-minute alarms from annunciating on TCO screens), except all alarms regardless of duration would be crucially traveling to the TCC for recording (Hollifield and Habibi, 2011; Schneider Electric UK, 2013).

**Mitigating Risks of Persistence.** As well as using redirection instead of generic persistence, if possible, there are other mitigations for reducing the risks associated with persistence.

- Telemetry technicians should be required to keep a spreadsheet detailing the length of persistence that has been added to all assets and continually update the spreadsheet if subsequent persistence is deemed necessary. This should prevent using persistence inappropriately on assets that already have had persistence applied, such as applying 5-minute persistence on an asset that has already had 1-hour persistence applied in the past.
- The alarm management team should engage asset operators and field managers involved in assets targeted by the alarm management team before applying persistence. This should ensure that inappropriate lengths of persistence are not applied to critical assets, assets with health and safety concerns, or assets in which persistence or redirection are not appropriate due to the nature of the processes involved.

- Any implementations of persistence/redirection should be audited. The assets affected should be monitored and evaluated to ensure that the applied persistence is having the desired effect of reducing nuisance alarms and is not detrimentally affecting the processes involved. The ISA alarm management life cycle structure is a good guide (ANSI/ISA, 2009) to achieving the above.

## **Conclusions and Implications**

An average of 57% of NI Water alarms have a duration of <5 minutes. Therefore, a 5-minute persistence could prevent an average of 26 816 nuisance alarms per week. Additionally, a time delay used with redirection could be applied with more confidence. The number of alarms NI Water TCOs have to contend with would be halved, with the severed half containing nuisance alarms. This would significantly reduce costs associated with overtime pay for TCOs as a result of alarm floods and call-outs for false alarms. The massive reduction in nuisance alarms would also have the positive effect of allowing the consideration of introducing more intelligent alarms to be met with less skepticism. The skepticism that meets any ideas of adding more alarms to the system is understandable considering the vast majority of nuisance alarms currently produced. New, more intelligent alarms, possibly as a result of integrating information from various sensors or even systemwide could be seriously considered by various parties involved (Barnett et al., 2004; Behbahani et al., 2012; Pleau et al., 2005; Roehl and Conrads, 1999; Severn Trent Water, 2010). On a small scale, 5-minute persistence is currently being applied across Network Water assets (service reservoirs [SR] and water pumping stations [WPS], etc.) nationwide in NI. Such alarms need to be explored further as they would bring NI Water closer to more advanced forms of real-time control and optimization. This would facilitate NI Water in meeting its responsibility

in helping to keep the environment clean.

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Persistence = 1 minute

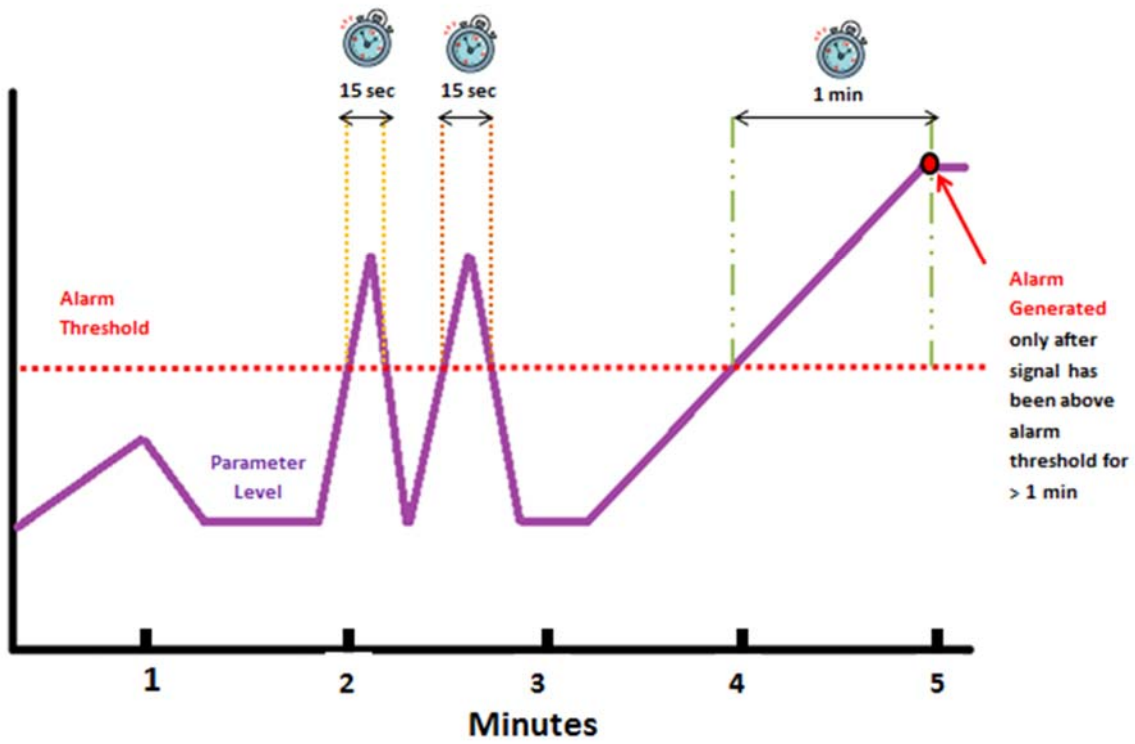


Figure 1. Example of an 1 minute persistence.



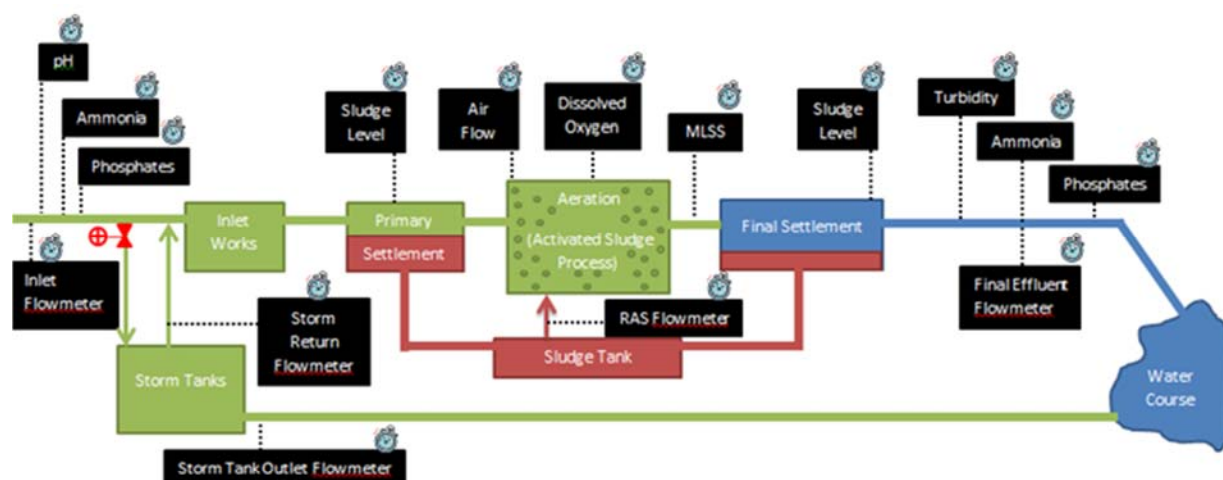


Figure 2. Example of alarmed sensors at asset points in a water treatment system.

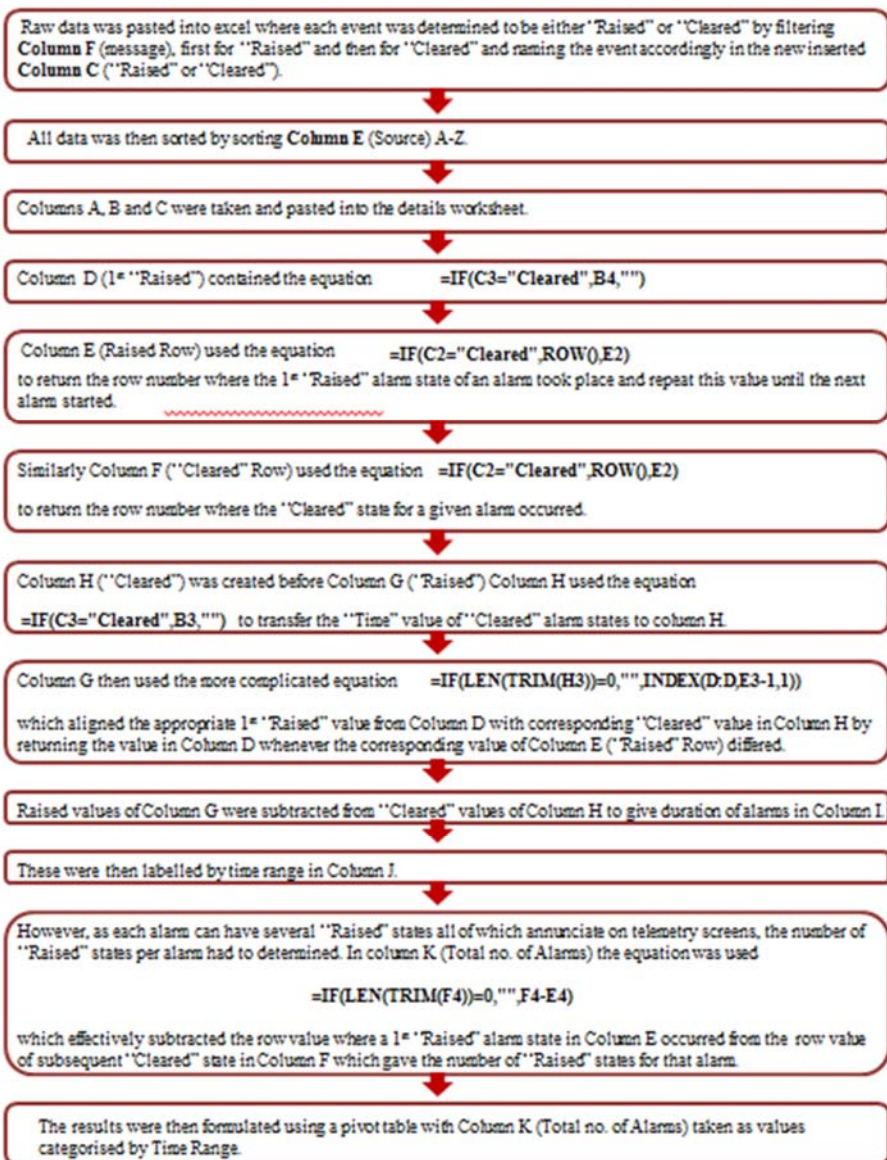


Figure 3. Flowchart of advanced excel procedure used to determine persistence.

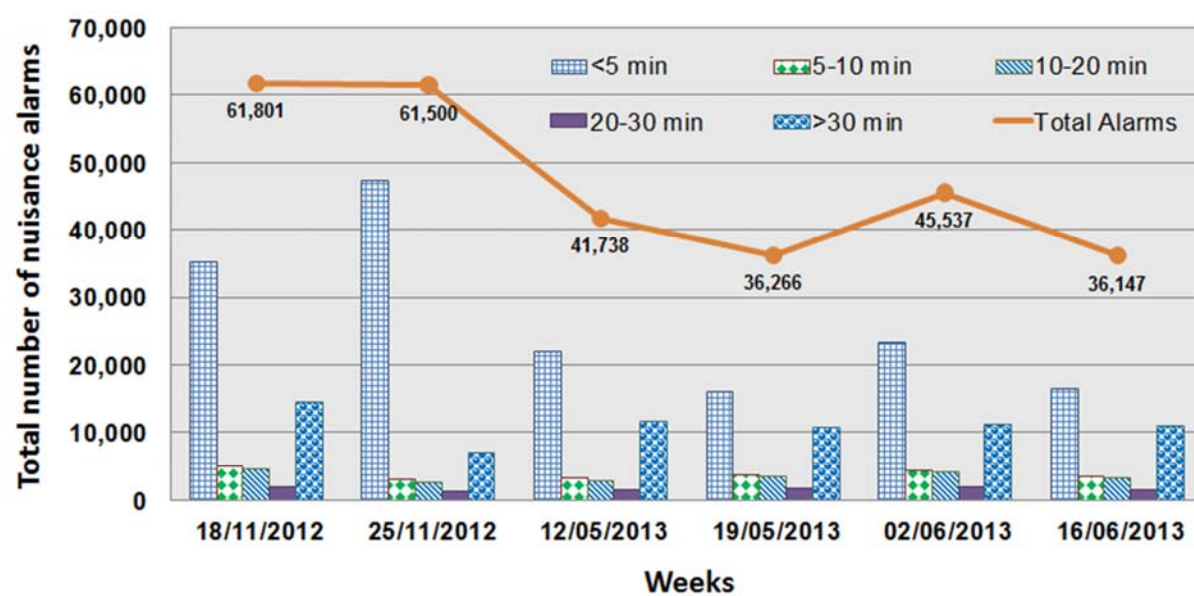


Figure 4. Distribution of percentage of alarm time groups measured for the weeks in Nov 2012, and May and June 2013.

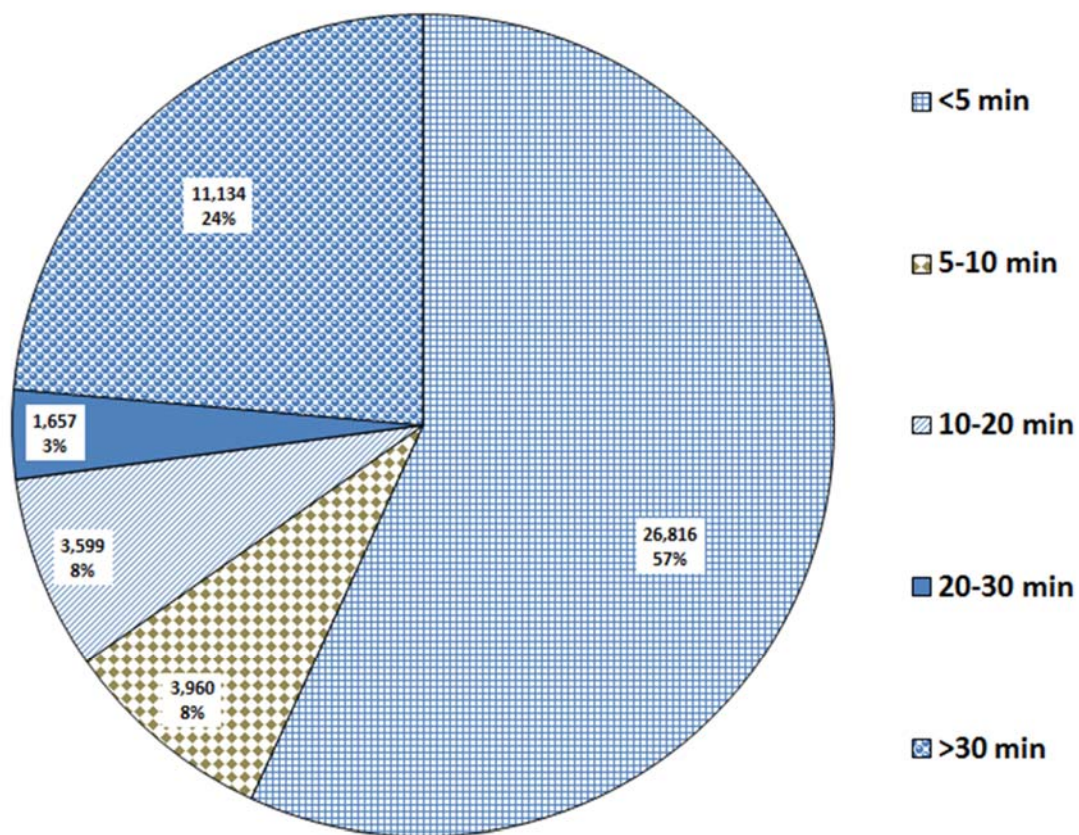


Figure 5. Average of alarms that occurred during weeks measured in Nov. 2012 and May and June 2013.

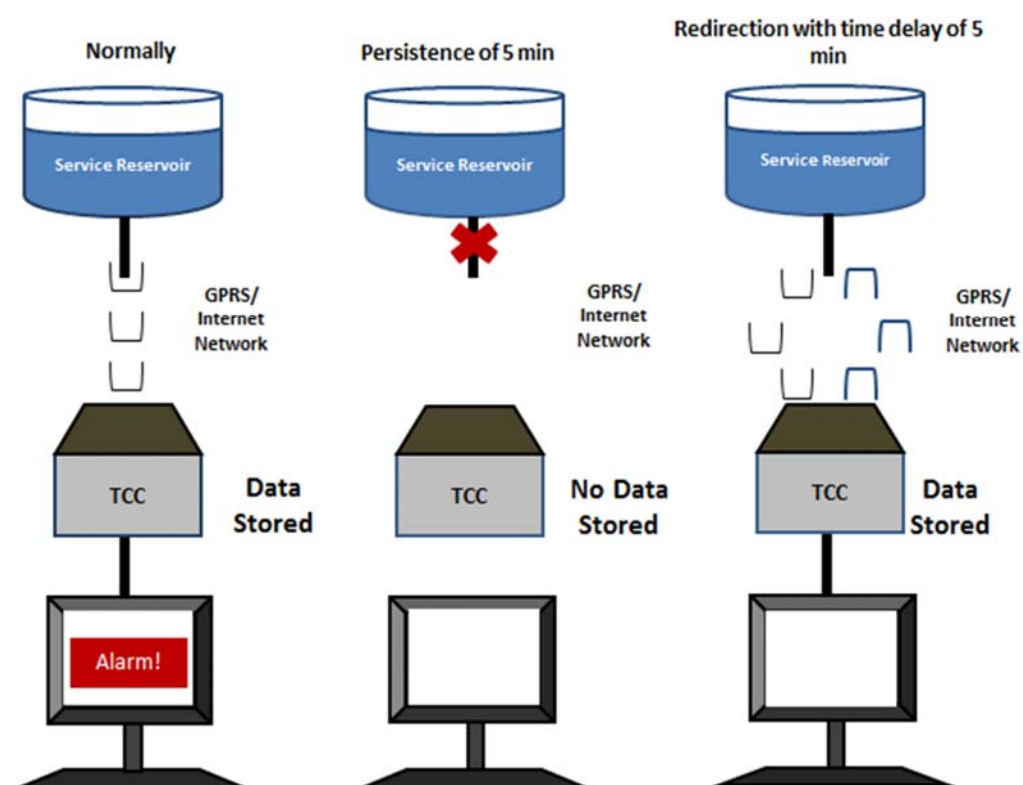


Figure 6. Comparison of applied persistence and redirection with transmission of data for alarms that last <5minutes.